CLAIMS

We Claim:

1. A laser apparatus for producing single mode large-area coherent lasing, comprising:

a feedback structure of a thickness T and of an average refractive index N, having a top surface and a bottom surface, said feedback structure having a refractive index variation between said top and said bottom surfaces in accordance with a predefined profile, such that said structure produces a photonic mode having a lasing threshold and being of a predetermined frequency, and a plurality of additional photonic modes, wherein said predefined profile is selected such that said predetermined frequency is greater than a value determined by a following expression:

$$F_L + c/2TN,$$

wherein F_L is a frequency of a nearest, to said predetermined frequency, lower frequency photonic mode of said plural additional photonic modes, and c is the speed of light in a vacuum;

a light-emitting medium disposed within said feedback structure, said light-emitting medium being configured to emit electromagnetic radiation at said predetermined frequency; and

variable excitation means, connected to said feedback structure, for exciting said light-emitting medium to produce optical gain of a predetermined gain magnitude in said feedback structure, said predetermined gain magnitude being sufficient to at least meet said lasing threshold to cause coherent wide-area laser emission to occur at said predetermined frequency perpendicular to at least one of said top and bottom surfaces,

wherein said wide-area laser emission remains coherent when said predetermined gain magnitude is selectively increased above said lasing threshold.

2. The laser apparatus of claim 1, wherein said photonic mode is one of a defect mode and a high frequency band edge mode.

3. The laser apparatus of claim 1, wherein said feedback structure comprises a plurality of dielectric material layers of at least two differing dielectric constants.

4. The laser apparatus of claim 1, wherein said light-emitting medium is composed of a material adapted to produce optical gain inside said feedback structure upon application of an electromagnetic wave thereto, and wherein said variable excitation means comprises an electromagnetic wave source configured to apply said electromagnetic wave to said feedback structure to excite said light-emitting medium to produce optical gain.

5. The laser apparatus of claim 4, wherein said electromagnetic wave source is one of: a laser, a flash lamp, focused sunlight, a light-emitting diode, and an electrically pumped electro-luminescent material embedded within said light-emitting medium.

6. The laser apparatus of claim 5, wherein said light-emitting medium comprises one of: rare earth doped material, chelated rare earth doped material, semiconductor materials, organic light-emitting materials, conjugated polymers, dye-doped material, and materials containing color centers.

7. The laser apparatus of claim 4, wherein said electromagnetic wave source comprises:

a diffuser having a plurality of edges and an emitting surface perpendicular to said plural edges; and

a tunable light-emitter operable to emit electromagnetic radiation into at least one of said plural edges such that electromagnetic radiation is scattered and emitted from said emitting surface, said emitted electromagnetic radiation being dispersed along said emitting surface and being generally perpendicular to one of said top and bottom surfaces of said feedback structure, and wherein when said predetermined gain magnitude resulting from excitation of said light-emitting medium by said electromagnetic radiation is above said lasing threshold, said feedback structure only produces laser emission at said predetermined frequency and having a wave vector substantially normal to at least one of said top and bottom surfaces.

8. The laser apparatus of claim 7, wherein said tunable light emitter comprises at least one LED strip positioned along and corresponding to at least one of said plural edges, each of said at least one LED strips being tunable to provide variable light output.

9. The laser apparatus of claim 1, wherein said light-emitting medium is composed of a material adapted to produce optical gain inside said feedback structure upon application of a charge current thereto, and wherein said variable excitation means comprises:

a plurality of electrodes connected to said feedback structure; and

a tunable electrical power source, connected to said plurality of electrodes for providing said charge current to said feedback structure to excite said light-emitting medium to produce optical gain inside said feedback structure.

10. A passive spatial electromagnetic radiation filter apparatus comprising:

a feedback structure having a top portion and a bottom portion of a thickness T and having an average refractive index N, said feedback structure being configured to produce a photonic mode of a predetermined frequency, said photonic mode being separated from a nearest lower frequency photonic mode by a frequency greater than determined in accordance with a following expression: c/2TN, wherein c is the speed of light in a vacuum; and

a source for emitting electromagnetic radiation at said predetermined frequency within a cone that is generally perpendicular to said feedback structure through said feedback structure, wherein said feedback structure only transmits electromagnetic radiation of said predetermined frequency and having a wave vector substantially normal thereto, such that said electromagnetic radiation is passively spatially filtered as it passes through said feedback structure.

11. The passive spatial electromagnetic radiation filter of claim 10, wherein said photonic mode is one of a defect mode and a high frequency band edge mode.

12. An electromagnetic radiation amplifier apparatus comprising:

a feedback structure having a top portion and a bottom portion of a thickness T and having an average refractive index N, said feedback structure being configured to produce a photonic mode of a predetermined frequency, said photonic mode being separated from a nearest, to said predetermined frequency, lower frequency photonic mode by a frequency greater than determined in accordance with a following expression: c/2TN, wherein c is the speed of light in a vacuum;

a light-amplifying medium disposed within said feedback structure and being configured to amplify electromagnetic radiation at said predetermined frequency;

an electromagnetic radiation source for emitting electromagnetic radiation at said predetermined frequency perpendicular to said feedback structure through said

first surface of said feedback structure into said structure, such that a beam emerges through said second surface, wherein said feedback structure only transmits electromagnetic radiation of said predetermined frequency having a wave vector substantially normal thereto; and

variable excitation means, connected to said feedback structure, for applying gain of a selected magnitude to said feedback structure to thereby externally control a coherence area of said emerging beam, wherein said gain:

a) ranges from a lower gain to a higher gain,

b) is below a lasing threshold, and

c) is sufficient to provide amplification for said emitted electromagnetic radiation at said predetermined frequency such that when said gain is changed between said lower gain and said higher gain, said electromagnetic radiation emitted from said second surface is amplified and changed in coherence area corresponding to said change in said gain.

13. The electromagnetic radiation amplifier apparatus of claim 12, wherein said photonic mode is one of a defect mode and a high frequency band edge mode.

14. The electromagnetic radiation amplifier apparatus of claim 12, wherein said feedback structure comprises a plurality of dielectric material layers of at least two differing dielectric constants.

15. A method for producing single mode large-area coherent lasing, comprising the steps of:

a) providing a feedback structure of a thickness T and of an average refractive index N, having a top surface and a bottom surface, said feedback structure having refractive index variation, between said top and said bottom surfaces in accordance with a predefined profile;

b) configuring said feedback structure by selecting said predefined profile such that said structure produces a photonic mode having a lasing threshold and being of a predetermined frequency, and a plurality of additional photonic modes of different frequencies, wherein said predefined profile is selected such that said predetermined frequency is greater than a value determined by a following expression:

$$F_L + c/2TN,$$

wherein F_L is a frequency of a nearest, to said predetermined frequency, lower frequency photonic mode of said plural additional photonic modes, and c is the speed of light in a vacuum;

c) providing a light-emitting medium disposed within said feedback structure, said light-emitting medium being configured to produce optical gain when subjected to excitation; and

d) exciting said light-emitting medium to produce said optical gain of a predetermined gain magnitude in said feedback structure, said predetermined gain magnitude being sufficient to at least meet said lasing threshold, such that coherent wide-area laser emission occurs at said predetermined frequency perpendicular to at least one

of said top and bottom surfaces, wherein said wide-area laser emission remains coherent when said predetermined gain magnitude is selectively increased above said lasing threshold.

16. The method of claim 15, wherein said photonic mode is one of a defect mode and a high frequency band edge mode.

17. A method for passively spatially filtering electromagnetic radiation utilizing a feedback structure, comprising the steps of:

a) providing a feedback structure of a thickness T and of an average refractive index N, having a top surface and a bottom surface, said feedback structure having refractive index variation, between said top and said bottom surfaces in accordance with a predefined profile;

b) configuring said feedback structure by selecting said predefined profile such that said structure produces a photonic mode having a lasing threshold and being of a predetermined frequency, and a plurality of additional photonic modes of different frequencies, wherein said predefined profile is selected such that said predetermined frequency is greater than a value determined by a following expression:

$$F_L + c/2TN,$$

wherein F_L is a frequency of a nearest, to said predetermined frequency, lower frequency photonic mode of said plural additional photonic modes, and c is the speed of light in a vacuum; and

c) emitting electromagnetic radiation, from an electromagnetic radiation source, at said predetermined frequency within a cone that is generally perpendicular to said feedback structure through said feedback structure, wherein said feedback structure only transmits electromagnetic radiation of said predetermined frequency and having a wave vector substantially normal thereto, such that said electromagnetic radiation is passively spatially filtered as it passes through said feedback structure.

18. The method of claim 17, wherein said photonic mode is one of a defect mode and a high frequency band edge mode.

19. A method for amplifying electromagnetic radiation utilizing a feedback structure comprising the steps of:

a) providing a feedback structure of a thickness T and of an average refractive index N, having a top surface and a bottom surface, said feedback structure having refractive index variation, between said top and said bottom surfaces in accordance with a predefined profile;

b) configuring said feedback structure by selecting said predefined profile such that said structure produces a photonic mode having a lasing threshold and being of

a predetermined frequency, and a plurality of additional photonic modes of different frequencies, wherein said predefined profile is selected such that said predetermined frequency is greater than a value determined by a following expression:

$$F_L + c/2TN,$$

wherein F_L is a frequency of a nearest, to said predetermined frequency, lower frequency photonic mode of said plural additional photonic modes, and c is the speed of light in a vacuum; and

c) providing a light-amplifying medium disposed within said feedback structure and being configured to amplify electromagnetic radiation at said predetermined frequency;

d) emitting electromagnetic radiation, from an electromagnetic radiation source, at said predetermined frequency perpendicular to said feedback structure through said first surface of said feedback structure into said structure, such that a beam emerges through said second surface, wherein said feedback structure only transmits electromagnetic radiation of said predetermined frequency having a wave vector substantially normal thereto; and

e) applying gain of a selective magnitude to said feedback structure, from a variable excitation device, to thereby externally control a coherence area of said emerging beam, wherein said gain:

1) ranges from a lower gain to a higher gain,

2) is below a lasing threshold, and

3) is sufficient to provide amplification for said emitted electromagnetic radiation at said predetermined frequency such that when said gain is selectively changed between said lower gain and said higher gain,. said electromagnetic radiation emitted from said second surface is amplified and changed in coherence area corresponding to said change in said gain.

20. The method of claim 19, wherein said photonic mode is one of a defect mode and a high frequency band edge mode.

21. The laser apparatus of claim 4, wherein said electromagnetic wave source comprises:

a diffuser having an emitting surface for contact with said top surface of said feedback structure and having a back surface; and

a tunable light-emitter operable to emit electromagnetic radiation into said back surface such that said electromagnetic radiation is scattered and emitted from said emitting surface, said emitted electromagnetic radiation being dispersed along said emitting surface and being generally perpendicular to said top surface of said feedback structure, and wherein when predetermined gain magnitude resulting from excitation of said light-emitting medium by said electromagnetic radiation is above said lasing threshold, said feedback structure only produces laser emission from said bottom surface at said predetermined frequency and having a wave vector substantially normal to said bottom surface.